

The background of the slide is a photograph of the International Space Station (ISS) in orbit above Earth. The station's complex structure, including its large solar panel arrays, is clearly visible against the deep blue of the planet's atmosphere. Below the station, the Earth's surface is shown with white clouds and brownish landmasses. The text is overlaid on this image.

NASA/ESA Hex-Chrome Project

**Technology Evaluation for Environmental Risk Mitigation
Principal Center
Matt Rothgeb**

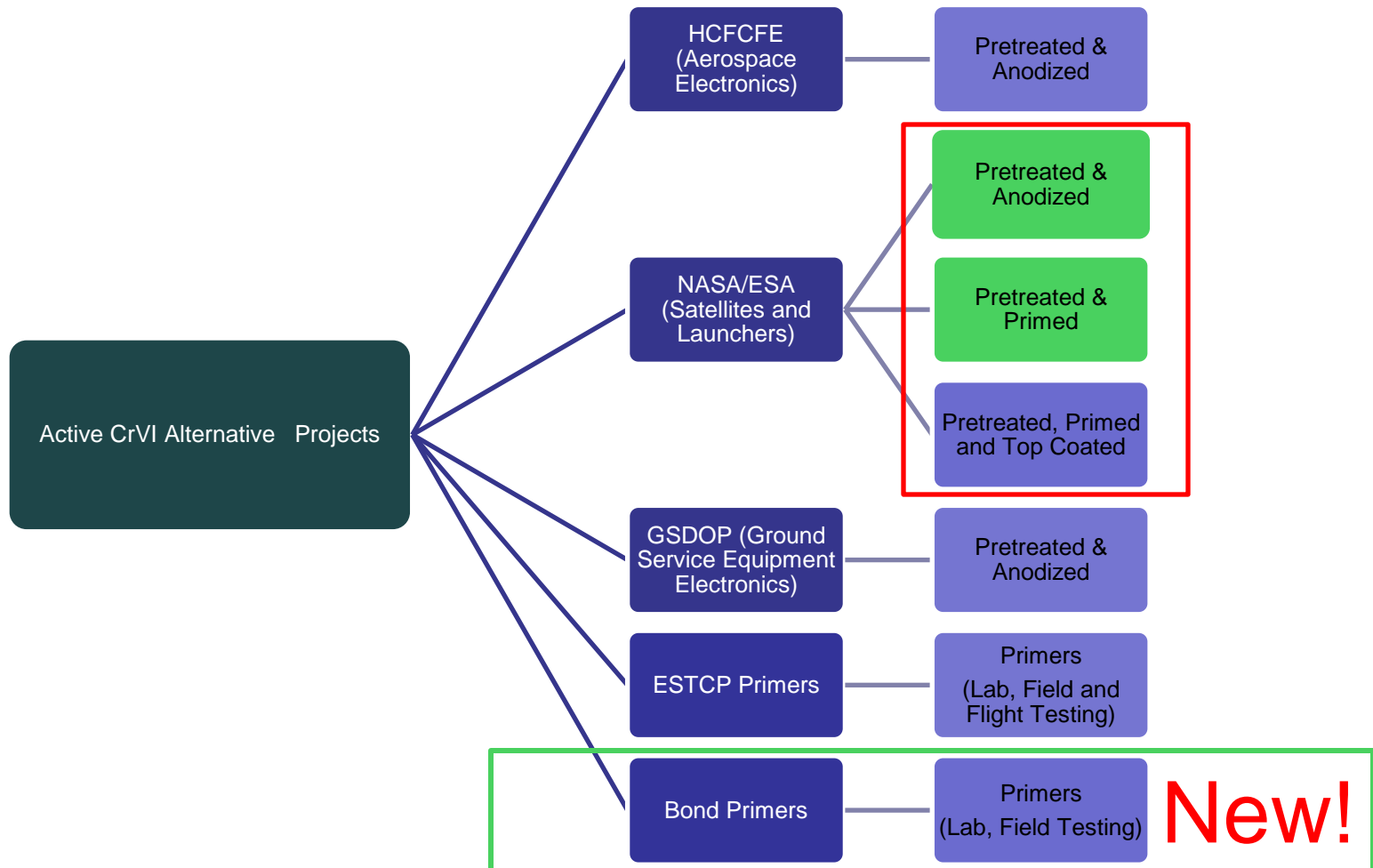
International Workshop on Environment and Alternative Energy

October 23, 2014

Kennedy Space Center, FL



Current NASA TEERM CrVI Projects:





NASA/ESA CrVI Alternatives - 3 Phase Project

Phase 1:

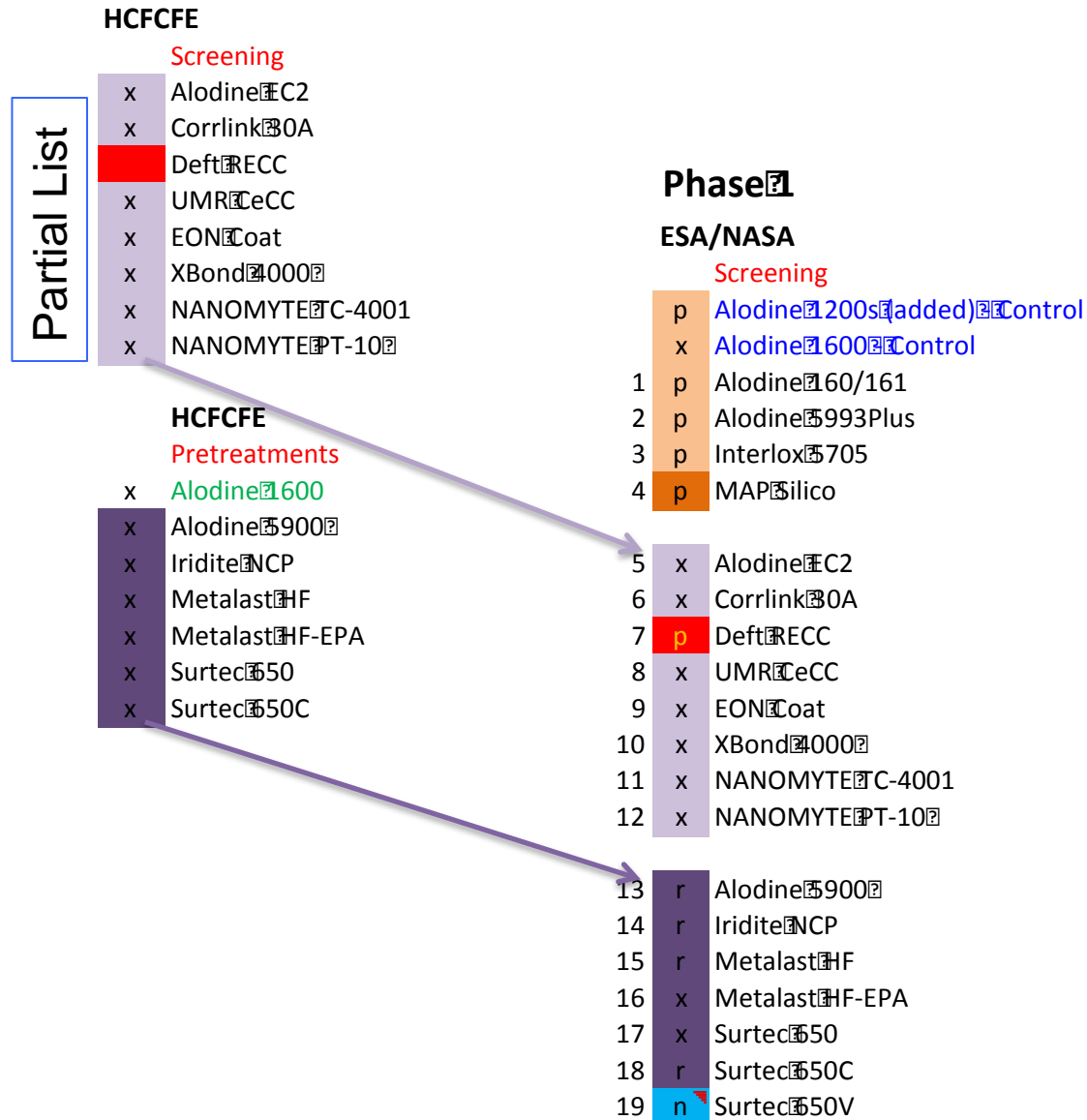
- Screening of Conversion Coatings - **COMPLETED**

Phase 2:

- Screening of Primers - **NEARLY COMPLETE – One Primer Remains in test**
- Extended testing of Conversion Coatings – **STARTING in CY2014**

Phase 3: - **NOT STARTED YET**

- Testing of best performing Conversion Coatings + Primers
- Testing of best performing Conversion Coatings + Primers + Topcoats





NASA/ESA Phase I Project Results & Overview of Next Phases



NASA/ESA (Phase 1) & HCFCFE Test Programs

Initial Screening Testing:

- ASTM B117 – Salt Fog to Failure
- ASTM G85 - Cyclic Corrosion (A5)
- Beachfront Exposure Testing
- Wet Tape Adhesion

Substrates:

- 2024 - T3
- 7075 - T73
- 6061 - T6

Initial Results:

- All Passed Adhesion
- Cyclic Corrosion was inconclusive
- Beachfront Analysis was inconclusive
- ASTM B117 Results showed mixed and unexpected results





Test Panel Preparation Process Optimization

- Initial Screening testing results were mixed on known commodities (Controls and Approved Non-Chromes)
- Initial re-testing did not provide clear answers
- Decision made to spend effort on optimization of pretreatment application and panel preparation processes
- \approx 5 Rounds of process optimization were conducted (Round considered major material or process change)



Test Panel Preparation Process Optimization

Round 1A

Substrates: 2024 / 2219 / 7075 / 6061
Cleaning: Scotch Bright + Ethanol



Test Panel Preparation Process Optimization

PROCESS 1

Cleaner

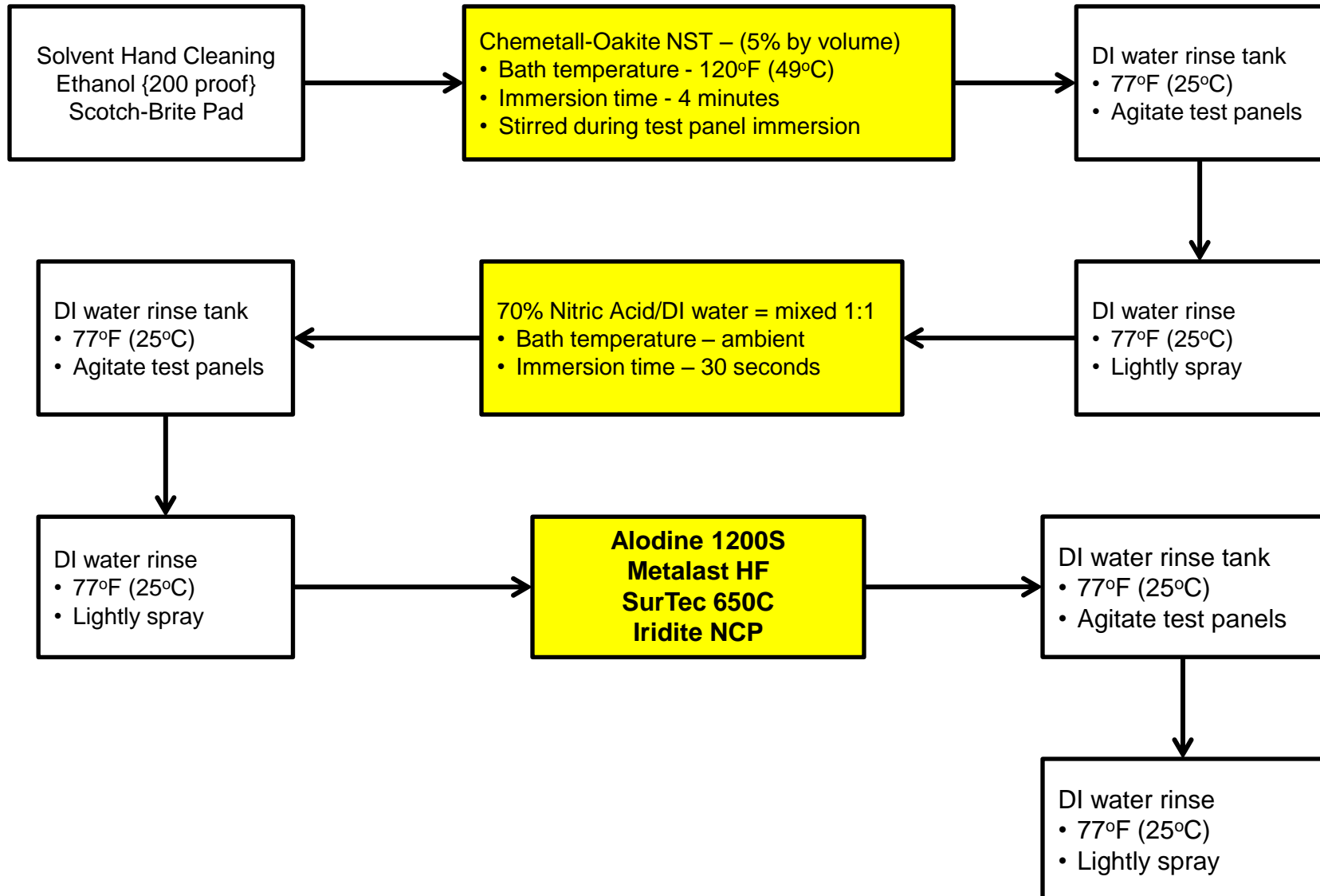
- Chemetall-Oakite NST – (5% by volume)

Deoxidizer

- 70% Nitric Acid/DI water = mixed 1:1 - agreed upon by stakeholder consensus



Process Optimization - Process 1





Test Panel Preparation Process Optimization

PROCESS 2

Cleaner

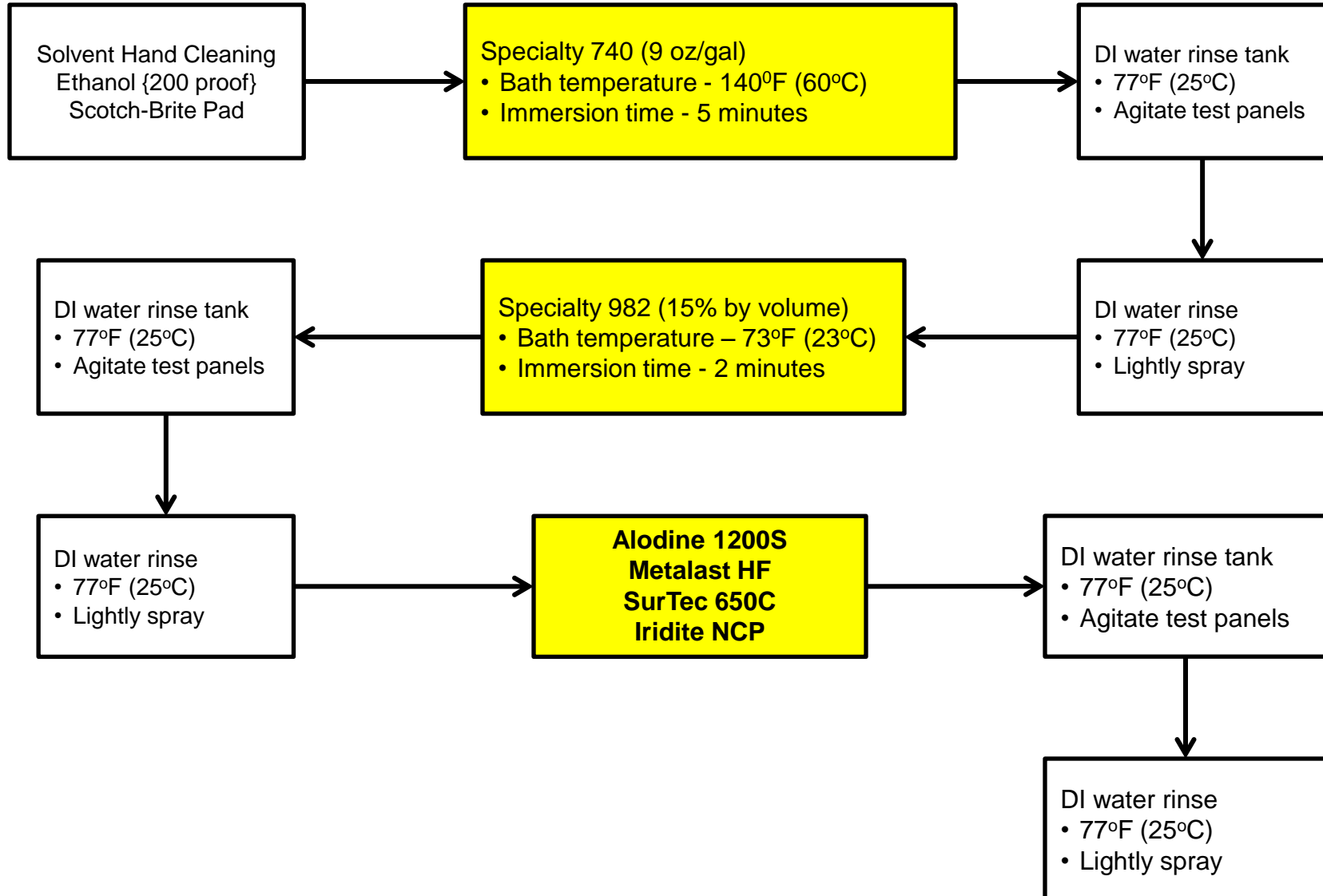
- Specialty 740 (9 oz/gal)

Deoxidizer

- Specialty 982 (15% by volume) – currently being used by local plating shop



Process Optimization - Process 2





Process Optimization

RESULTS:

- **Alodine 1200S**

- Failures on 2219 – Expected
- Failures on 2024 – **Not Expected (<168 Hours)**
- Passing on 6061 & 7075 – 336 Hours +

- **Metalast TCP**

- Failures on 2219 – Expected
- Passing on 2024 – Expected **168 Hours (barely)**
- Passing on 6061 & 7075 – 672 Hours +

- **Surtec 650 C**

- Failures on 2219 – Expected
- Failures on 2024 – **Not Expected (<168 Hours)**
- Passing on 6061 & 7075 – 504 Hours +



Optimization Iterations

- 5 Iterations were completed that incorporated a variety of substrates, cleaners and deoxidizers.
- 12+ Months to complete optimization to stakeholder satisfaction



Round - 1B

- Focusing on hardest alloys to protect
 - 2024-T3
 - 2219-T8
 - 7075-T6
- Alodine 1200S – alter contact times for deoxidizer {Specialty 982 (20% by volume) only} and Alodine bath
- Hexavalent chrome-free alternatives – alter contact time for deoxidizer only
 - 70% Nitric Acid/DI water = mixed 1:1 - agreed upon by stakeholder consensus
 - Specialty 982 (20% by volume) – currently being used by local plating shop



Round 2

- Changing initial solvent cleaning process
 - Replace ethanol (200 proof) to methyl ethyl ketone (MEK)
- Eliminating the use of Scotch-Brite pads
- Eliminated Nitric Acid Deoxidizer
- Alloys:
 - 2024-T3
 - 5052-H32 (ADDED AS PART OF GSDOP)
 - 6061-T6 (ADDED AS PART OF GSDOP)



Round 3

- Changing initial solvent cleaning process
 - Replace ethanol (200 proof) to methyl ethyl ketone (MEK)
- Eliminating the use of Scotch-Brite pads
- Eliminated Nitric Acid Deoxidizer
- Alloys:
 - 2024-T3
 - 5052-H32 (ADDED AS PART OF GSDOP)
 - 6061-T6 (ADDED AS PART OF GSDOP)



Round 4

- Changing initial solvent cleaning process
 - Replace ethanol (200 proof) to methyl ethyl ketone (MEK)
- Eliminating the use of Scotch-Brite pads
- Eliminated Nitric Acid Deoxidizer
- Alloys:
 - 2024-T3
 - 5052-H32 (ADDED AS PART OF GSDOP)
 - 6061-T6 (ADDED AS PART OF GSDOP)



Round 5A

- Changing initial solvent cleaning process
 - Replace ethanol (200 proof) to methyl ethyl ketone (MEK)
- Eliminating the use of Scotch-Brite pads
- Eliminated Nitric Acid Deoxidizer
- Alloys:
 - 2024-T3
 - 5052-H32 (ADDED AS PART OF GSDOP)
 - 6061-T6 (ADDED AS PART OF GSDOP)



Round 5B

- Changing deoxidizer times for Turco Smut-Go NC
 - Brackets around previous Round (60 seconds)
 - 0s, 10s, 30s, 120s
- Only evaluating 2024-T3
- Removed Alodine 1200S
- Removed Surtec 650 C



Round 5C

- Tested only Alloy 2219 (limited quantity available)
 - Clad test Panels scrubbed with Scotch-Brite pads to a dull surface
 - Bare test panels; no Scotch-Brite scrubbing
- Tested only Surtec 650V



Summary of Phase 1 Project Results



HCFCFE

Screening

x	Alodine EC2
x	Corrlink 30A
	Deft RECC
x	UMR CeCC
x	EON Coat
x	XBond 4000
x	NANOMYTE TC-4001
x	NANOMYTE PT-10

HCFCFE

Pretreatments

x	Alodine 1600
x	Alodine 5900
x	Iridite NCP
x	Metalast HF
x	Metalast HF-EPA
x	Surtec 350
x	Surtec 350C

Phase 1

ESA/NASA

Screening

p	Alodine 1200s (added) Control
x	Alodine 1600 Control
1	p Alodine 160/161
2	p Alodine 5993Plus
3	p Interlox 5705
4	p MAP Silico
5	x Alodine EC2
6	x Corrlink 30A
7	p Deft RECC
8	x UMR CeCC
9	x EON Coat
10	x XBond 4000
11	x NANOMYTE TC-4001
12	x NANOMYTE PT-10
13	r Alodine 5900
14	r Iridite NCP
15	r Metalast HF
16	x Metalast HF-EPA
17	x Surtec 350
18	r Surtec 350C
19	n Surtec 350V



Phase 2 Plans and Results to Date



Screening (phase 2)

ESA/NASA

Screening PT+PR

Alodine 200S	+	Koropon
MAP Silico	+	MAP Silico
MAP Silico	+	Deft 084
MAP Silico	+	Hentzen 16708
MAP Silico	+	PM820
Alodine 5923 Plus	+	MAP Silico
Alodine 5923 Plus	+	Deft 084
Alodine 5923 Plus	+	Hentzen 16708
Alodine 5923 Plus	+	PM820
Metalast TCP	+	MAP Silico
Metalast TCP	+	Deft 084
Metalast TCP	+	Hentzen 16708
Metalast TCP	+	PM820
SurTec 650V	+	MAP Silico
SurTec 650V	+	Deft 084
SurTec 650V	+	Hentzen 16708
SurTec 650V	+	PM820
MAP Silico	+	NAVALCOAT
Alodine 5923 Plus	+	NAVALCOAT
Metalast TCP	+	NAVALCOAT
Surtec 650V	+	NAVALCOAT

Substrate:

- 2024-T3

Testing:

- ASTM B117 – Salt Fog
- Adhesion – PATTI Jr.



Phase 2

ESA/NASA

Pretreatments

Alodine 1200S

Iridite 14-2

Metalast TCP

MAP Silico

Alodine 5923Plus

SurTec 350V

Substrates:

- 2024-T3
- 2024-T8
- 6061-T6
- 7075-T6
- 7075-T73

Testing:

- B117 – Salt Fog – NASA/ESA
- Humidity Exposure - ESA
- Thermal Cycling - ESA
- Adhesion – X-Cut Tape – NASA
- Resistivity - ESA



Phase 2 - Test Data – CC+Primers Matrix

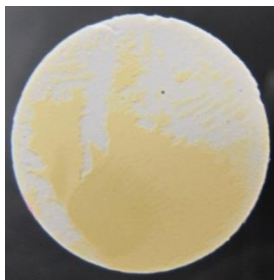
- PATTI Pull – Complete
- Salt Spray – Complete; 2,100 hours
- MAP Silico Primer (processed by MAP)
 - Round 1 – Pulled at 1,055 hours (Failed - Unexpected)
 - Round 2 – Started \approx 1,000 hours



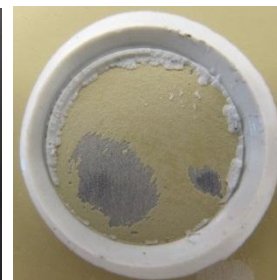
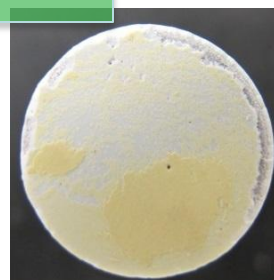
PATTI Pull Adhesion Test Results – Metalast TCP

Conversion Coat	Primer	Alloy	Panel ID	DFT (mils)	Failure Mode	Pull-Off Tensile Strength (psi)	Percentage Difference	Comments
Metalast TCP	Hentzen 16708	2024-T3	20907	1.66	60% adhesive / 10% cohesive / 30% glue	3123	11.91	
			20908	1.62	40% adhesive / 20% cohesive / 40% glue	3519		
Metalast TCP	Deft 02GN084	2024-T3	21007	1.94	90% adhesive / 10% glue*	2690	3.61	*Test panels were lightly sanded and wiped clean prior to placing the dolly
			21008	1.85	85% adhesive / 15% glue*	2789		
Metalast TCP	NAVALCOAT	2024-T3	21107	2.17	60% adhesive / 40% glue	2768	32.53	
			21108	2.59	10% adhesive / 90% glue	1993		

20907



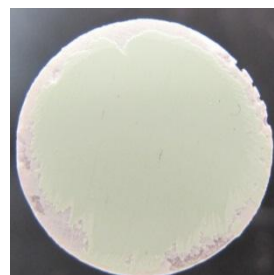
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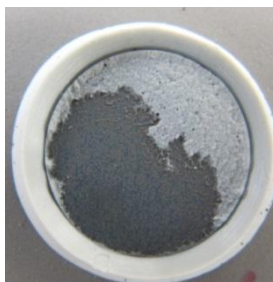
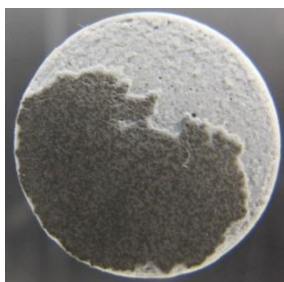
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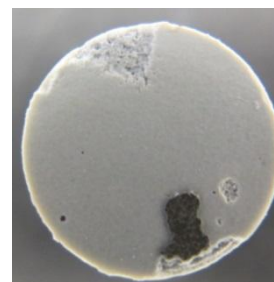
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21107



21108

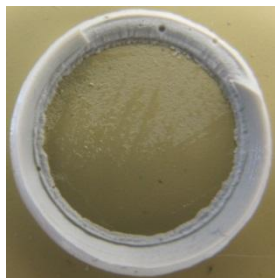
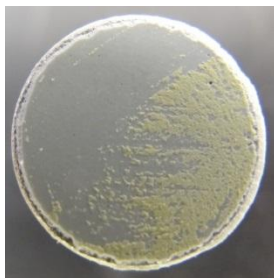




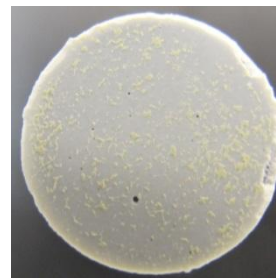
PATTI Pull Adhesion Test Results – SurTec 650V

Conversion Coat	Primer	Alloy	Panel ID	DFT (mils)	Failure Mode	Pull-Off Tensile Strength (psi)	Percentage Difference	Comments
SurTec 650V	Hentzen 16708	2024-T3	21307	2.5	30% cohesive / 70% glue	3003	9.04	
			21308	3.31	20% cohesive / 80% glue	3288		
SurTec 650V	Deft 02GN084	2024-T3	21407	2.03	80% adhesive / 20% glue*	2038	32.35	*Test panels were lightly sanded and wiped clean prior to placing the dolly
			21408	2.01	100% glue*	2826		
SurTec 650V	NAVALCOAT	2024-T3	21507	2.36	30% adhesive / 70% glue*	3077	3.54	*Test panels were lightly sanded and wiped clean prior to placing the dolly
			21508	1.9	100% adhesive	2970		

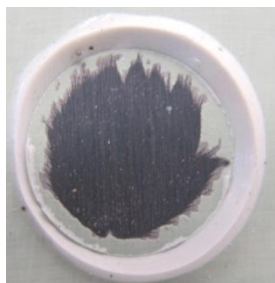
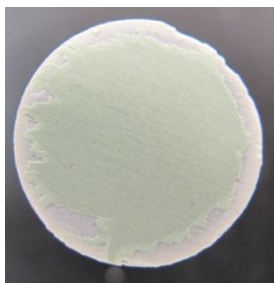
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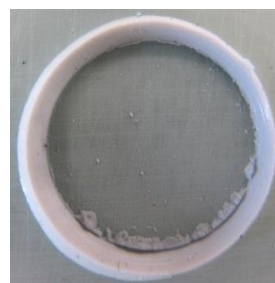
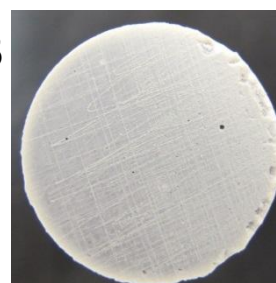
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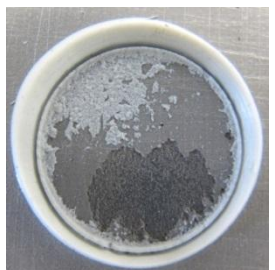
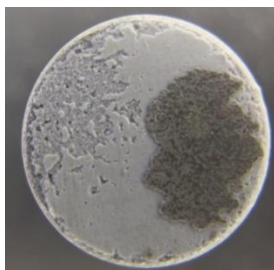
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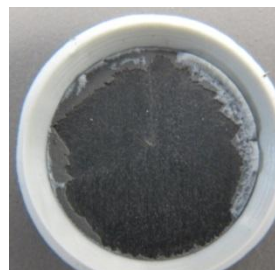
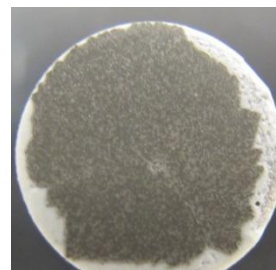
21408



21507



21508

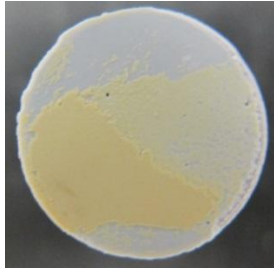




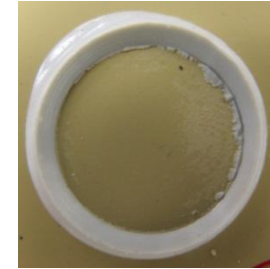
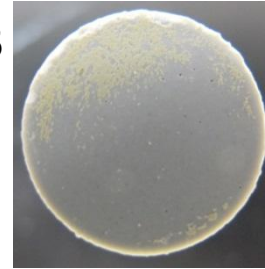
PATTI Pull Adhesion Test Results – Alodine 5923plus

Conversion Coat	Primer	Alloy	Panel ID	DFT (mils)	Failure Mode	Pull-Off Tensile Strength (psi)	Percentage Difference	Comments
Alodine 5923plus	Hentzen 16708	2024-T3	21707	2.42	33% adhesive / 33% cohesive / 33% glue	2579	19.86	
			21708	2.52	25% cohesive / 75% glue	3148		
Alodine 5923plus	Deft 02GN084	2024-T3	21807	1.96	95% adhesive / 5% glue*	1032	84.73	*Test panels were lightly sanded and wiped clean prior to placing the dolly
			21808	1.85	95% adhesive / 5% glue*	2554		
Alodine 5923plus	NAVALCOAT	2024-T3	21907	2.5	100% glue*	3416	16.36	*Test panels were lightly sanded and wiped clean prior to placing the dolly
			21908	2.44	100% adhesive	2805		

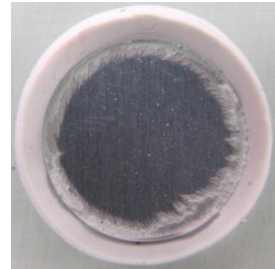
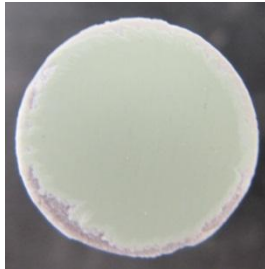
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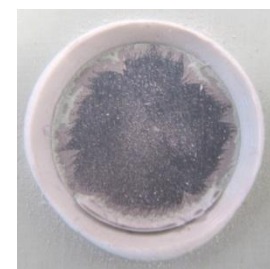
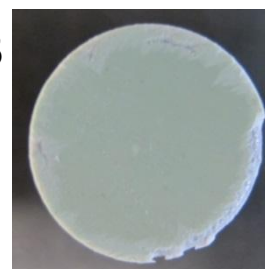
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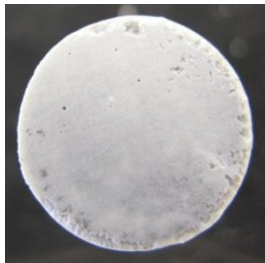
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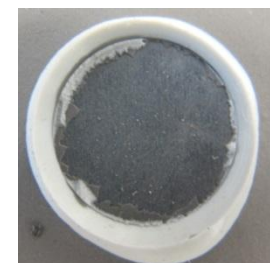
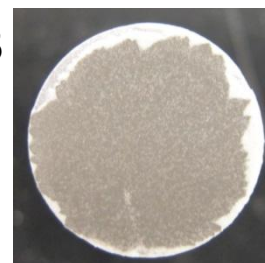
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21907



21908

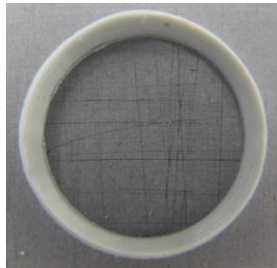
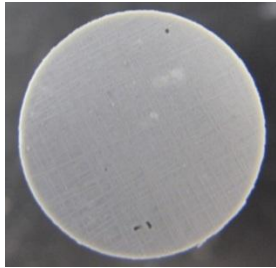




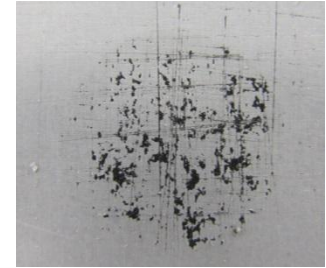
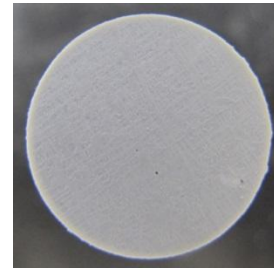
PATTI Pull Adhesion Test Results – MAPSIL SILICo Thick

Conversion Coat	Primer	Alloy	Panel ID	DFT (μm)	Failure Mode	Pull-Off Tensile Strength (psi)	Percentage Difference	Comments
MAPSIL® SILICo {12 to 16 μm}		2024-T3	20507	14	100% glue*	616	2.63	*Test panels were lightly sanded and wiped clean prior to placing the dolly
			20508	14	45% adhesive / 55% glue*	632		
MAPSIL® SILICo {12 to 16 μm}		2024-T3	MAP X 7	15	5% adhesive / 95% glue*	876	8.11	*Test panels were lightly sanded and wiped clean prior to placing the dolly
			MAP X 8	12	100% glue*	950		

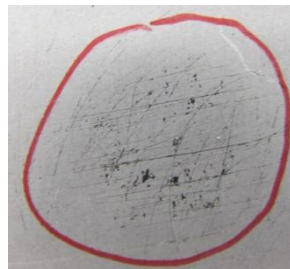
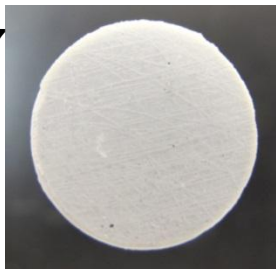
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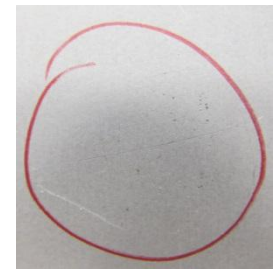
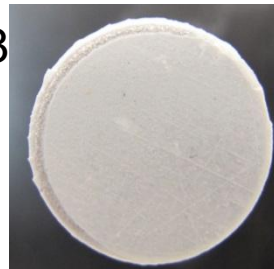
20508



MAP X7



MAP X8





ASTM B 117 Salt Spray Testing

Panel Rating Methodology

1st Digit - Scribe Appearance	
0	Bright and clean
1	Staining, minor corrosion but no build up
2	Minor/moderate corrosion product build up
3	Moderate corrosion product build up
4	Major corrosion product build up
5	Severe corrosion product build up

2nd Digit - Undercutting / Blistering @ Scribe	
0	No lifting of coating
1	Lifting or loss of adhesion up to 1/16" (2 mm)
2	Lifting or loss of adhesion up to 1/8" (3 mm)
3	Lifting or loss of adhesion up to 1/4" (7 mm)
4	Lifting or loss of adhesion up to 1/2" (13 mm)
5	Lifting or loss of adhesion beyond 1/2" (>13 mm)

Size - 3rd Digit - Blistering Away from the Scribe	
0 = None	Frequency
1 = Very Small up to 1/16" (2 mm)	F = Few
2 = Small up to 1/8" (3 mm)	M = Medium
3 = Small to Medium up to 1/4" (7 mm)	MD = Med. Dense
4 = Medium to Large up to 1/2" (13 mm)	D = Dense
5 = Large (>13 mm)	



ASTM B 117 Salt Spray Testing

Evaluation 4 - 2,100 hours of exposure

1st Digit - Scribe Appearance		2nd Digit - Undercutting / Blistering @ Scribe		Size - 3rd Digit - Blistering Away from the Scribe	
0	Bright and clean	0	No lifting of coating	0 = None	Frequency
1	Staining, minor corrosion but no build up	1	Lifting or loss of adhesion up to 1/16" (2 mm)	1 = Very Small up to 1/16" (2 mm)	F = Few
2	Minor/moderate corrosion product build up	2	Lifting or loss of adhesion up to 1/8" (3 mm)	2 = Small up to 1/8" (3 mm)	M = Medium
3	Moderate corrosion product build up	3	Lifting or loss of adhesion up to 1/4" (7 mm)	3 = Small to Medium up to 1/4" (7 mm)	MD = Med. Dense
4	Major corrosion product build up	4	Lifting or loss of adhesion up to 1/2" (13 mm)	4 = Medium to Large up to 1/2" (13 mm)	D = Dense
5	Severe corrosion product build up	5	Lifting or loss of adhesion beyond 1/2" (>13 mm)	5 = Large (>13 mm)	

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit			Notes - Comments
					Reading	Isolated	Size	Freq	Isolated	
Metalast TCP	Hentzen 16708	2024-T3	20904	3	0	N/A	1	MD	Yes	Blistering - top half of test panel; not edge effect; could be coating thickness issue
			20905	3	0	N/A	1	MD	Yes	Blistering - top half of test panel; not edge effect; could be coating thickness issue
			20906	4	0	N/A	1	M	Yes	Blistering - top half of test panel; not edge effect; could be coating thickness issue
Metalast TCP	Deft 02GN084	2024-T3	21104	3	1	No	2	F	Yes	Blistering - bottom right corner. not edge effect; could be coating thickness issue
			21005	3	0	N/A	2	F	Yes	Blistering - very top of panel; not edge effect; could be coating thickness issue
			21006	3	1	No	0	N/A	N/A	
Metalast TCP	NAVALCOAT	2024-T3	21004	3	0	N/A	1	MD	No	Blistering on lower half of the panel, forming near the scribe but does not appear to be undercutting. Blisters formed at the top edge of the panel. Coating has been removed from some of the blisters exposing bare aluminum.
			21105	3	0	N/A	2	MD	No	Blistering on lower half of the panel, forming near the scribe but does not appear to be undercutting. A few blisters are located on the top half of the panel. Blisters formed at the top edge of the panel as well as along the right edge and bottom corners. Coating has been removed from some of the blisters exposing bare aluminum.
			21106	3	0	N/A	2	MD	No	Blistering on lower half of the panel, forming near the scribe but does not appear to be undercutting. A few blisters are located on the top half of the panel. Blisters formed at the top edge of the panel as well as the bottom corners. Coating has been removed from some of the blisters exposing bare aluminum.

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit			Notes - Comments
					Reading	Isolated	Size	Freq	Isolated	
SurTec 650V	Hentzen 16708	2024-T3	21304	3	2	No	0	N/A	N/A	
			21305	3	2	No	0	N/A	N/A	
			21306	3	2	No	0	N/A	N/A	
SurTec 650V	Deft 02GN084	2024-T3	21404	3	2	No	0	N/A	N/A	
			21405	3	1	No	0	N/A	N/A	
			21406	3	1	No	0	N/A	N/A	
SurTec 650V	NAVALCOAT	2024-T3	21504	3	0	N/A	1	F	Yes	1 blister found on the top half of the panel, could be aggregate
			21505	3	0	N/A	1	F	Yes	1 blister found on the bottom half of the panel, could be aggregate. Blistering on lower right corner.
			21506	3	0	N/A	1	F	No	3 pits on lower left side away from the scribe, 1 one very close to the edge. 2 blisters were found away from the scribe. Blisters on bottom corners and along the top edge. Coating has been removed from some of the blisters exposing bare aluminum.



ASTM B 117 Salt Spray Testing

Evaluation 4 - 2,100 hours of exposure										
1st Digit - Scribe Appearance		2nd Digit - Undercutting / Blistering @ Scribe				Size - 3rd Digit - Blistering Away from the Scribe				
0	Bright and clean	0	No lifting of coating			0 = None	Frequency			
1	Staining, minor corrosion but no build up	1	Lifting or loss of adhesion up to 1/16" (2 mm)			1 = Very Small up to 1/16" (2 mm)	F = Few			
2	Minor/moderate corrosion product build up	2	Lifting or loss of adhesion up to 1/8" (3 mm)			2 = Small up to 1/8" (3 mm)	M = Medium			
3	Moderate corrosion product build up	3	Lifting or loss of adhesion up to 1/4" (7 mm)			3 = Small to Medium up to 1/4" (7 mm)	MD = Med. Dense			
4	Major corrosion product build up	4	Lifting or loss of adhesion up to 1/2" (13 mm)			4 = Medium to Large up to 1/2" (13 mm)	D = Dense			
5	Severe corrosion product build up	5	Lifting or loss of adhesion beyond 1/2" (>13 mm)			5 = Large (>13 mm)				
Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit			Notes - Comments
					Reading	Isolated	Size	Freq	Isolated	
Alodine 5923plus	Hentzen 16708	2024-T3	21704	1	0	N/A	1	F	Yes	1 blisted found at the top right edge of the panel
			21705	1	0	N/A	1	F	Yes	1 blister at the top center edge of the panel
			21706	1	0	N/A	1	F	Yes	2 blisters at the top right edge of the panel
Alodine 5923plus	Deft 02GN084	2024-T3	21804	3	1	Yes	0	N/A	N/A	
			21805	3	1	Yes	0	N/A	N/A	
			21806	3	1	Yes	0	N/A	N/A	
Alodine 5923plus	NAVALCOAT	2024-T3	21904	3	0	N/A	0	N/A	N/A	Blistering / coating removal on bottom edge / corners
			21905	3	0	N/A	0	N/A	N/A	Blistering / coating removal on bottom edge / corners
			21906	3	0	N/A	0	N/A	N/A	Blistering on bottom edge / corners
Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit			Notes - Comments
					Reading	Isolated	Size	Freq	Isolated	
MAPSIL® SILiCo {12 to 16 µm}		2024-T3	20501							PULLED FROM TESTING AFTER 1,055 HOURS
			20502							PULLED FROM TESTING AFTER 1,055 HOURS
			20503							PULLED FROM TESTING AFTER 1,055 HOURS
MAPSIL® SILiCo {12 to 16 µm}		2024-T3	MAP X 1							PULLED FROM TESTING AFTER 1,055 HOURS
			MAP X 2							PULLED FROM TESTING AFTER 1,055 HOURS
			MAP X 3							PULLED FROM TESTING AFTER 1,055 HOURS



ASTM B 117 Salt Spray Testing Metalast TCP

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
Metalast TCP	Hentzen 16708	2024-T3	20904	3	0	N/A	1	MD	Yes
			20905	3	0	N/A	1	MD	Yes
			20906	4	0	N/A	1	M	Yes

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
Metalast TCP	Deft 02GN084	2024-T3	21104	3	1	No	2	F	Yes
			21005	3	0	N/A	2	F	Yes
			21006	3	1	No	0	N/A	N/A

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
Metalast TCP	NAVALCOAT	2024-T3	21004	3	0	N/A	1	MD	No
			21105	3	0	N/A	2	MD	No
			21106	3	0	N/A	2	MD	No



ASTM B 117 Salt Spray Testing

SurTec 650V

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
SurTec 650V	Hentzen 16708	2024-T3	21304	3	2	No	0	N/A	N/A
			21305	3	2	No	0	N/A	N/A
			21306	3	2	No	0	N/A	N/A

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
SurTec 650V	Deft 02GN084	2024-T3	21404	3	2	No	0	N/A	N/A
			21405	3	1	No	0	N/A	N/A
			21406	3	1	No	0	N/A	N/A

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
SurTec 650V	NAVALCOAT	2024-T3	21504	3	0	N/A	1	F	Yes
			21505	3	0	N/A	1	F	Yes
			21506	3	0	N/A	1	F	No



ASTM B 117 Salt Spray Testing Alodine 5923plus

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
Alodine 5923plus	Hentzen 16708	2024-T3	21704	1	0	N/A	1	F	Yes
			21705	1	0	N/A	1	F	Yes
			21706	1	0	N/A	1	F	Yes

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
Alodine 5923plus	Deft 02GN084	2024-T3	21804	3	1	Yes	0	N/A	N/A
			21805	3	1	Yes	0	N/A	N/A
			21806	3	1	Yes	0	N/A	N/A

Conversion Coat	Primer	Alloy	Panel ID	1st Digit Scribe	2nd Digit		3rd Digit		
					Reading	Isolated	Size	Freq	Isolated
Alodine 5923plus	NAVALCOAT	2024-T3	21904	3	0	N/A	0	N/A	N/A
			21905	3	0	N/A	0	N/A	N/A
			21906	3	0	N/A	0	N/A	N/A



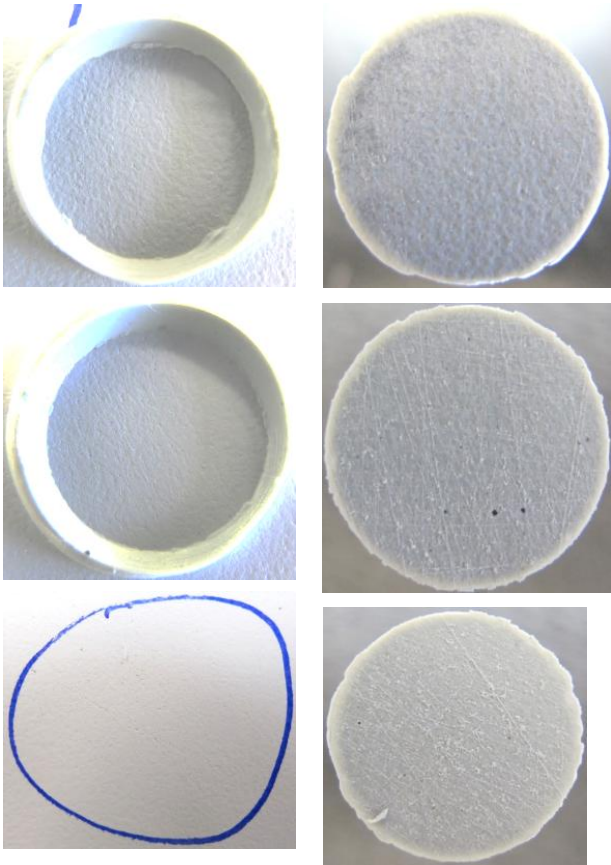
Test Panel Evaluation
Chrome Free Conversion Coatings with
MAPSIL SILICo AS
MAPSIL SILICo {Thick}



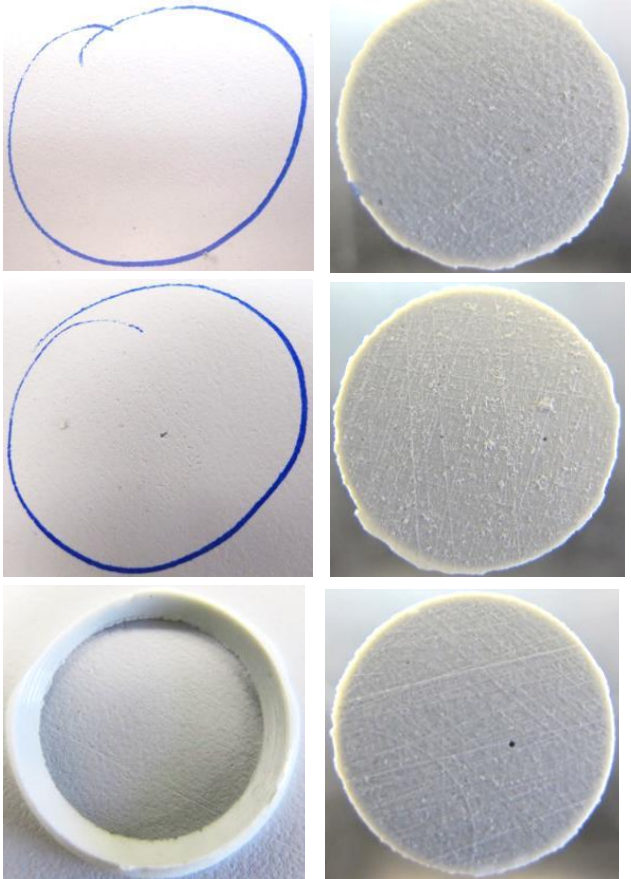
PATTI Pull Adhesion Test Results – Metalast TCP

Conversion Coat	Primer	Alloy	Panel ID	DFT (um)	Piston	Burst Pressure (psi)	Failure Mode	Pull-Off Tensile Strength (psi)
Metalast TCP	MAPSIL SILICo AS	2024-T3	21207	62	F-4	40.5	100% glue	835
						45.9	100% glue	947
						10.5	100% glue	215
			21208	57	F-4	28.1	100% glue	579
						12.1	100% glue	248
						46.3	100% glue	955

21207



21208

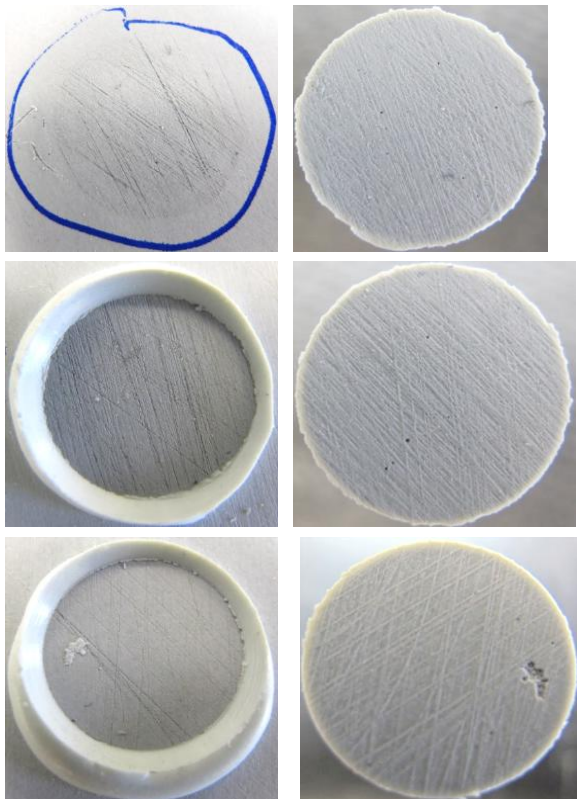




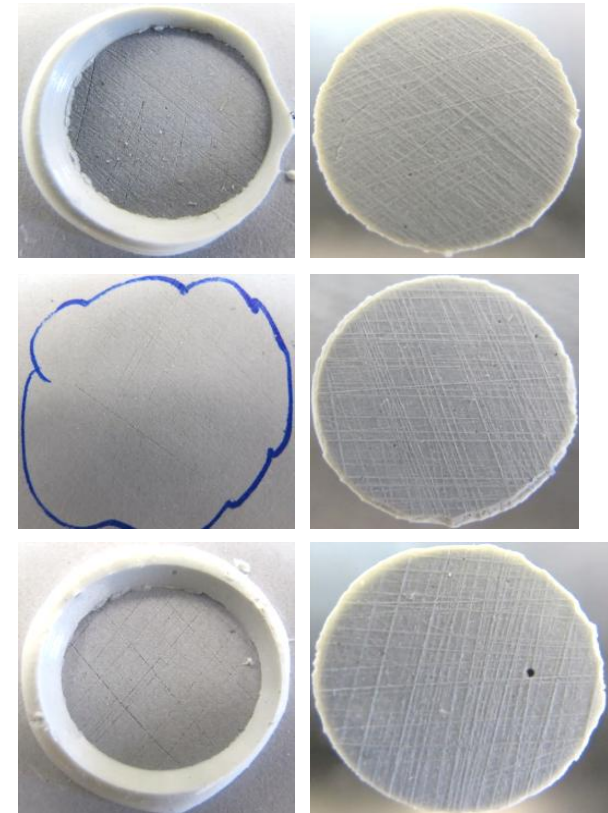
PATTI Pull Adhesion Test Results – Metalast TCP

Conversion Coat	Primer	Alloy	Panel ID	DFT (um)	Piston	Burst Pressure (psi)	Failure Mode	Pull-Off Tensile Strength (psi)
Metalast TCP	MAPSIL SILICo	2024-T3	MS107	19	F-4	9.3	100% glue	191
						34.9	100% glue	719
						44.6	100% glue	920
			MS108	19	F-4	45.0	100% glue	928
						46.0	100% glue	949
						9.6	100% glue	197

MS 107



MS 108

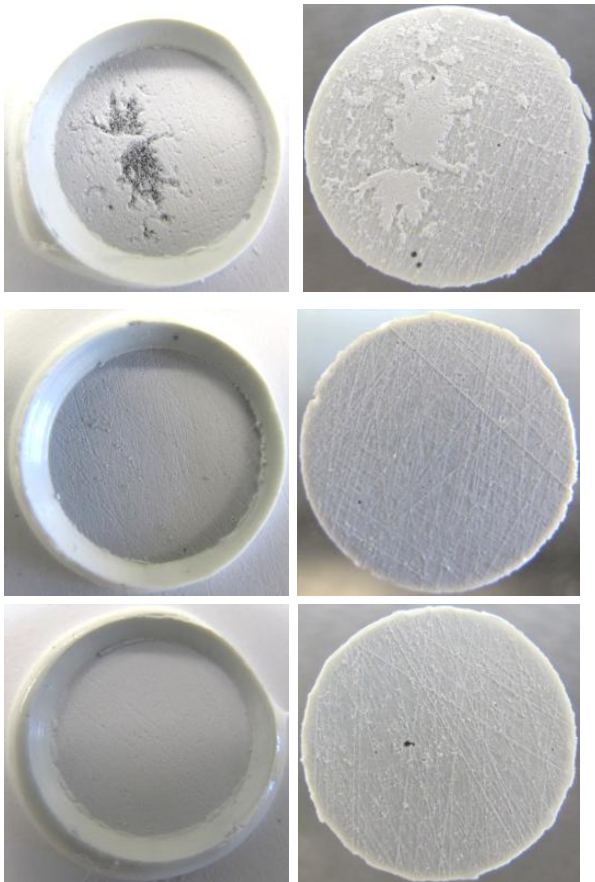




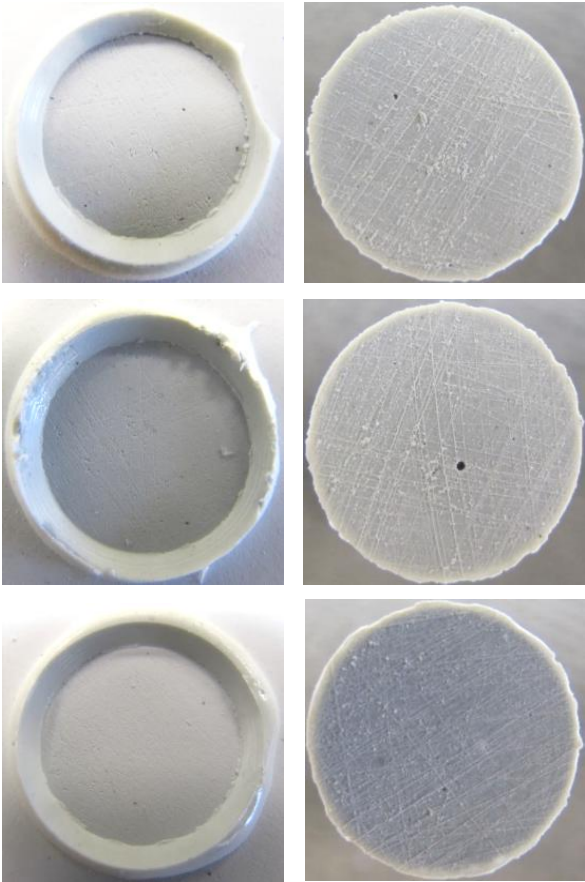
PATTI Pull Adhesion Test Results – SurTec 650V

Conversion Coat	Primer	Alloy	Panel ID	DFT (um)	Piston	Burst Pressure (psi)	Failure Mode	Pull-Off Tensile Strength (psi)
SurTec 650V	MAPSIL SILICo AS	2024-T3	21607	65	F-4	17.9	20% adhesive / 80% glue	368
						50.8	100% glue	1048
						47.7	100% glue	984
			21608	66	F-4	17.9	100% glue	368
						17.5	100% glue	360
						43.8	100% glue	903

21607



21608

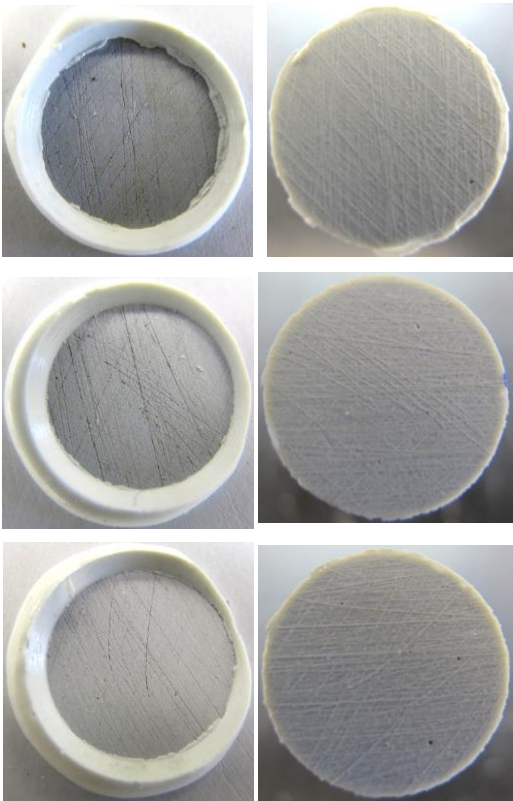




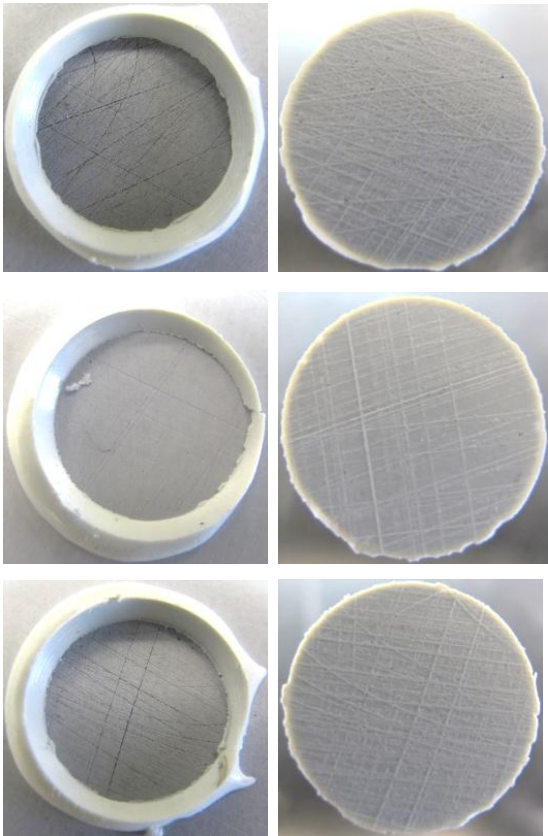
PATTI Pull Adhesion Test Results – SurTec 650V

Conversion Coat	Primer	Alloy	Panel ID	DFT (um)	Piston	Burst Pressure (psi)	Failure Mode	Pull-Off Tensile Strength (psi)
SurTec 650V	MAPSIL SILICo	2024-T3	MS115	24	F-4	44.7	100% glue	922
						47.1	100% glue	971
						44.2	100% glue	912
			MS116	22	F-4	35.6	100% glue	734
						33.9	100% glue	699
						10.3	100% glue	211

MS 115



MS 116

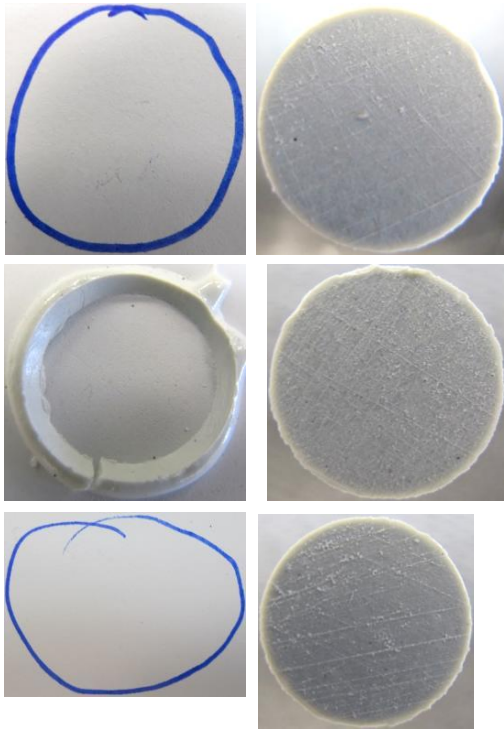




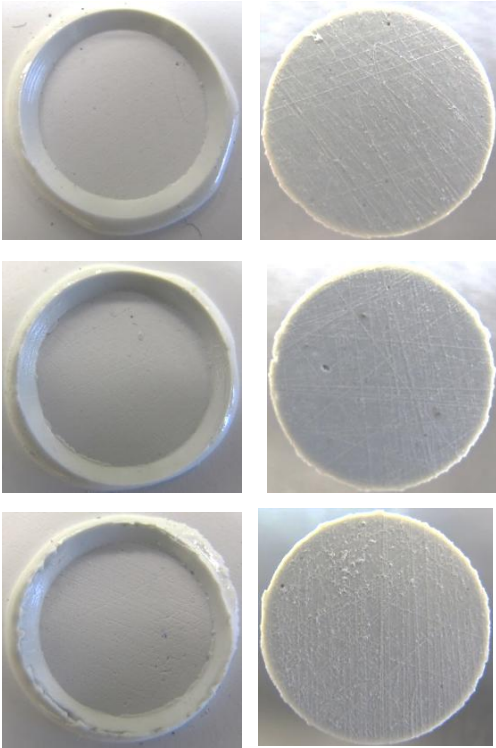
PATTI Pull Adhesion Test Results – Alodine 5923plus

Conversion Coat	Primer	Alloy	Panel ID	DFT (um)	Piston	Burst Pressure (psi)	Failure Mode	Pull-Off Tensile Strength (psi)
Alodine 5923plus	MAPSIL SILICo AS	2024-T3	22007	61	F-4	46.6	100% glue	961
						58.3	100% glue	1203
						27.0	100% glue	556
			22008	61	F-4	46.5	100% glue	959
						45.8	100% glue	945
						42.7	100% glue	881

22007



22008

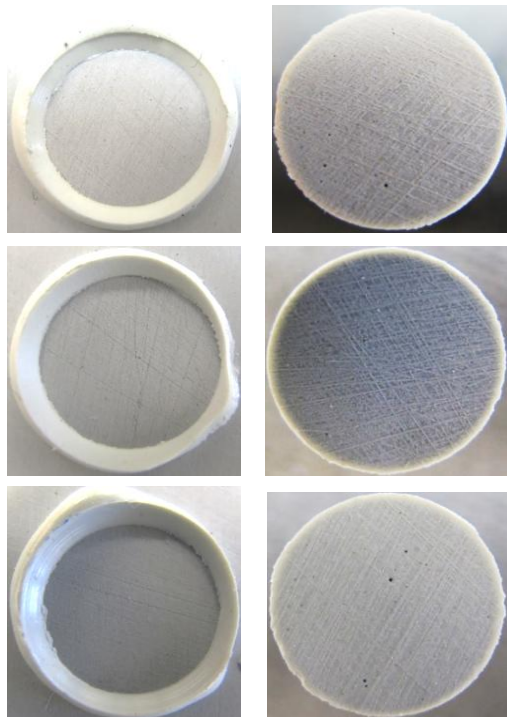




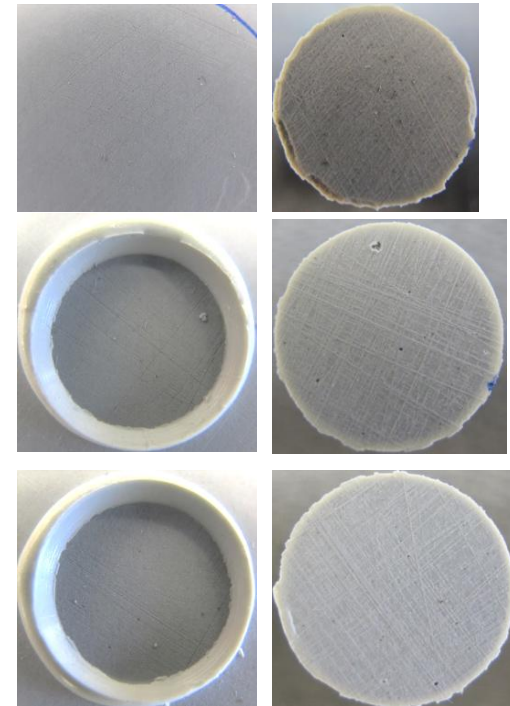
PATTI Pull Adhesion Test Results – Alodine 5923plus

Conversion Coat	Primer	Alloy	Panel ID	DFT (um)	Piston	Burst Pressure (psi)	Failure Mode	Pull-Off Tensile Strength (psi)
Alodine 5923plus	MAPSIL SILICo	2024-T3	MS123	20	F-4	46.8	100% glue	965
						50.2	100% glue	1036
						33.0	100% glue	680
			MS124	17	F-4	50.5	100% glue	1042
						44.8	100% glue	924
						42.7	100% glue	881

MS 123



MS 124





Phase B

ESA/NASA

Pretreat+Primer

Alodine 200S	+ PR (NASA Control)
Iridite 14-2	+ PR (ESA Control)
Metalast TCP	+ PR1 (NASA Alternative 1)
MAP Silico	+ PR2 (NASA Alternative 2)
Alodine 5923 Plus	+ PR3 (ESA Alternative 1)
SurTec 350V	+ PR4 (ESA Alternative 2)

Substrates:

- 2024-T3
- 2024-T8
- 6061-T6
- 7075-T6
- 7075-T73

Testing:

- B117 – Salt Fog
- Atmospheric Exposure
- Adhesion - X-Cut Tape
- Adhesion – PATTI Jr.



Phase B

ESA/NASA

Pretreat+Primer+Topcoat

Alodine 1200S	+	PR	+	TC	(NASA Control)
Iridite 14-2	+	PR	+	TC	(ESA Control)
Metalast TCP	+	PR1	+	TC	(NASA Alternative 1)
MAP Silico	+	PR2	+	TC	(NASA Alternative 2)
Alodine 5923 Plus	+	PR3	+	TC	(ESA Alternative 1)
SurTec 350V	+	PR4	+	TC	(ESA Alternative 2)

Substrates:

- 2024-T3
- 2024-T8
- 6061-T6
- 7075-T6
- 7075-T73

Testing:

- B117 – Salt Fog
- Atmospheric Exposure
- Adhesion - X-Cut Tape
- Adhesion – PATTI Jr.

THANK YOU!

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A Soyuz spacecraft is being mated to the International Space Station (ISS) by a robotic arm. The Soyuz is suspended in the air, with its solar panels extended. The ISS structure is visible in the background. The Earth's surface is visible below, with a bright green aurora borealis (Northern Lights) illuminating the sky. The text "Any Questions?" is overlaid on the right side of the image.

Any Questions?